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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a **PROVISIONAL APPLICATION FOR PATENT** under 37 CFR 1.53 (b)(2).

Docket Number	27027	Type a plus sign (+) inside this box ->	+

INVENTOR(s) / APPLICANT(s)

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TITLE OF THE INVENTION (280 characters max)

DISTRIBUTED CELL BALANCING

15535 U.S. PTO 60/513586 102403

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ **Specification**	*Number of Pages*	**10**	☑ **Applicant is entitled to Small Entity Status**
☑ **Drawing(s)**	*Number of Sheets*	**2**	☑ **Other** (specify) **16 CLAIMS**

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☐ A check or money order is enclosed to cover the filing fees ☑ The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number:	**50-1407**	**FILING FEE AMOUNT ($)**	**$ 80.-**

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☑ No

☐ Yes, the name of the US Government agency and the Government contract number are: ________________

Respectfully submitted,

SIGNATURE ________________________________ Date **October 22, 2003**

REGISTRATION NO. *(if appropriate)* 25,457

TYPED or PRINTED NAME **SOL SHEINBEIN**

☐ Additional inventors are being named on separately numbered sheets attached hereto

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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Distributed cell balancing

Introduction

Conventional cellular networks employ an architecture which divides a geographical area into coverage areas, called cells, and a base station is placed at the center of the cell to serve the cellular traffic within the cell.

To increase the capacity (the total data or the total number of users served) the cell is further divided into sectors (typically 3 sectors), which are served from the same base location, using dedicated baseband resources, tranceivers and directional antennas, per sectors.

A coverage problem might arise due to "radio holes", that is regions within the cell/sector which suffer large propagation losses induced by uneven topography and urban areas, impairing the quality of service.

Another problem which might arise is "hot spots", where a large concentration of users, usually not in the vicinity of the base station, causes an excessive load on the cell's radio resources.

Both problems can be addressed using repeaters.

Repeaters can improve coverage of "radio holes" by placing them in geographic locations which have good radio coverage of the problematic areas, while maintaining good connectivities to the base station.

Similarly, repeaters can increase the capacity required by "hot spots" by reducing the required transmit power (both uplink and downlink) to achieve a good quality of service. This is especially relevant to CDMA systems, where the capacity is interference limited.

In both cases, the repeaters are deployed within the sector to improve the coverage and the capacity of the sector and optimize the sector's radio resources allocation.

However, while each sector might be optimizes with regards to its own resource allocation, we could have, within the cell, sectors which are heavily loaded, requiring

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additional capacity, while other sectors might be lightly loaded having some spare capacity.

This load unbalance between the sectors could be the result of non-optimal network design, or due to changes in communication pattern since the the cellular system was originally installed.

In other cases, load unbalance could be of temporary nature, changing periodically (for example, according to time of the day or day of the week) or it could be event driven.

Thus it might be advantageous to dynamically balance the load between sectors, by transfering some load from a heavily loaded sector to other sectors which are lightly loaded.

Patent applications WO 02/061878 "ANTENNA ARRANGEMENTS FOR FLEXIBLE COVERAGE OF A SECTOR IN A CELLULAR NETWORK", and US Provisional Patent Application No. 60/442,890 filed January 28, 2003 "SYSTEM AND METHOD FOR LOAD DISTRIBUTION BETWEEN SECTORS, describe an approach based on changing the direction (azimuth) and width of the sectors, by controlling the shape of the antennas patterns.

By narrowing a heavy loaded sectors while widening other lightly loaded sectors we can balance the load in the cell and improve overall system performance.

Another approach is to reduce the load of a heavy loaded sector by tilting the antenna and thus shrinking the range of the sector (and of the cell in that direction), transferring the load to the neighbor cell. This could be done in conjunction with the previously mentioned cell shaping.

The present invention describes a load sharing mechanism, where loads in hot-spots in one sector are connected and served by sectors which are less loaded. This is done by the use of repeaters and not by changing the antenna patterns and shaping the sectors or the cell.

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Summary of the Invention

We consider a sectored cell, where hot-spots in each sector are local, each served by its own repeater, and may draw high capacity at different times. Load sharing is applied between sectors by connecting repeaters which are located in one sector (the loaded sector) to other sectors which are less loaded. This is accomplished by connecting the repeater to the donor sector base station using frequency F2. The repeater converts the transmission back to F1, the original frequency of the donor base station. Softer handoff is applied between the repeaters and the sectors in which they are located.

Load balancing is performed and maintained by using a control subsystem, which measures the load in each sector, as well as the load served by each repeater, and an optimization algorithm, which dynamically assign repeaters to sectored base stations, using a switching matrix.

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Detailed description

Figure 1 depicts a situation where hot spots in each sector are local and may draw high capacity at different times. It may be desired to draw, at a given time, the capacity of sector α, for example, to the hotspots 4,5,6 (which are located within the coverage area of sector β). This way, the lightly loaded sector α takes some of the load of the heavy loaded sector β.

The follwing solutions are discussed here:

1. Fiber linking to each repeater (or any other point-to point linking)
2. RF linking to the repeaters
    a. Availability of one or multiple cellular/ PCS band frequencies, unused in this cluster of cells
    b. Availability of another multicarrier band (e.g. unlicensed band such as 5.8 GHz) for the linkage between the BTS and the repeaters

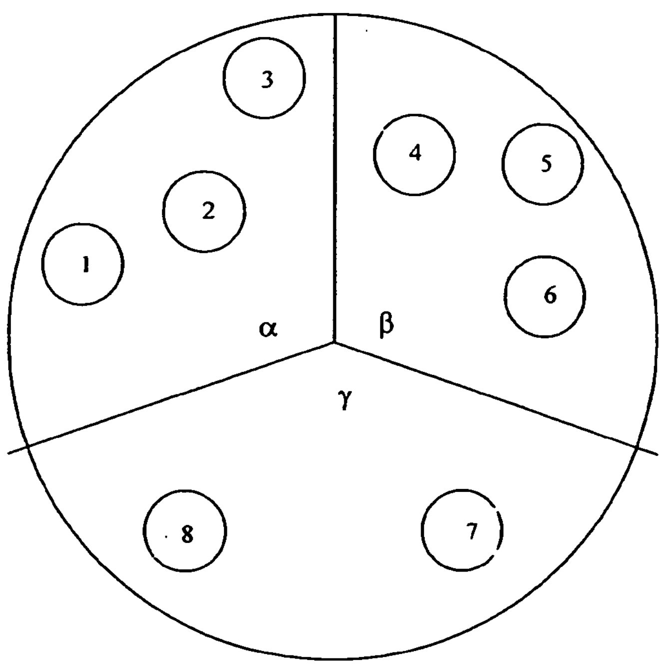

Figure 1: Sectored cell with local coverage repeaters

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In one embodiment of the invention the RF linking to the repeaters is done in an unused frequency (frequencies) in the PCS/Cellular band, using the existing transmit/receive antennas

The system is depicted in Figure 2. F1 is the carrier frequency used by all sectors to communicate with the mobile subscribers. F2 is the carrier frequency used by all sectors to communicate with the repeaters. The sector transmission is translated from F1 to F2 before being transmitted to the repeater (using the existing antennas).

The switching matrix assigns the transmission of one sector to the repeaters of any sector (including its own). It can switch one sectors to the repeaters of two (or even three) sectors.

Note that the combiners are required for transmission from the BTS sector antennas. The combiners may entail a loss, which is avoidable if transmission can be made from separate antennas. Availability of separate sector antennas is a matter of licensing and cost. The diversity receive-only antenna can also be duplexed for this purpose.
There are several configurations of this embodiment as follows:

a) Single carrier (F1) translated into a single link frequency (F2)

b) This configuration may be extended to multi carrier frequencies, where such carriers are available and not in use in that cluster. In such a case there is a translation from a number of carriers in use (F1 group), one-to-one, to another set of carriers (F2 group). Repeaters may be braodband, translating from F2 group back to F1 group. The resource allocation control in this case is per sector.

c) Individual repeater may be tuned to a different carrier in the F2 group, which is then translated to the respective F1 group members. This offers an additional degree of resource allocation control, at the individual repeater level.

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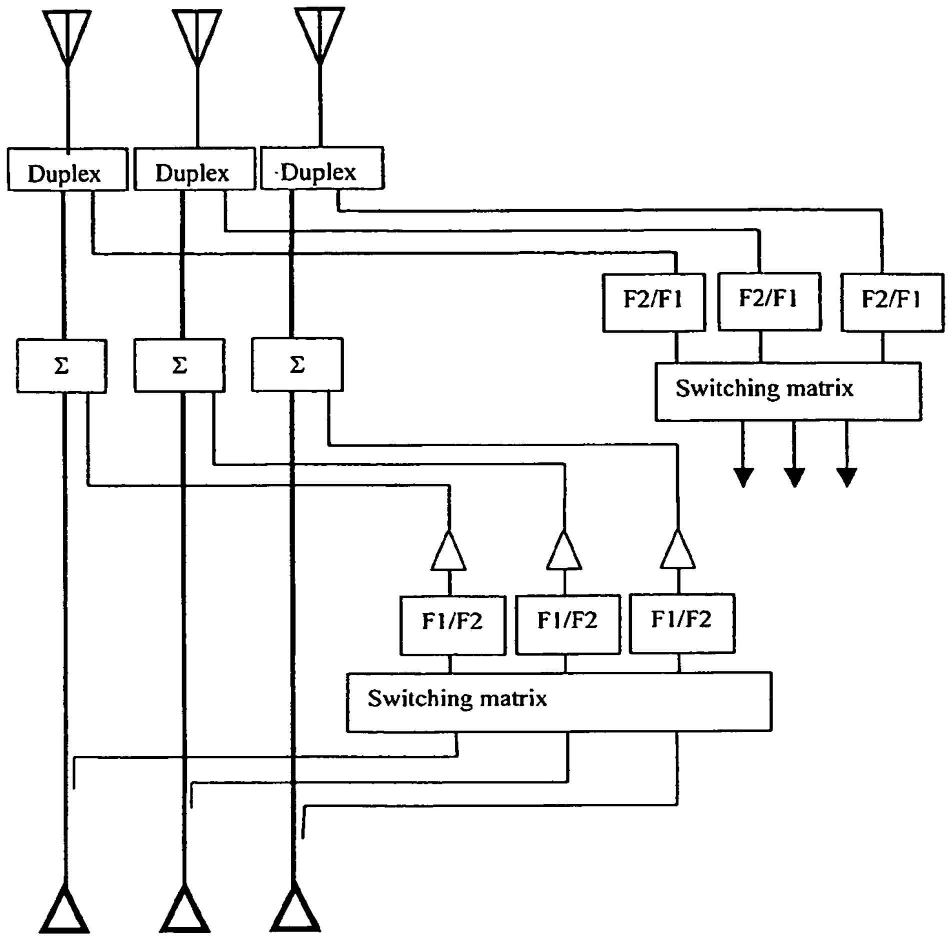

Figur2: RF linking to repeaters in PCS/Cellular band

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In another embodiment of the invention, we have a point-to-point microwave linkage between the repeaters and the BTS using dedicated antennas (one for each repeater). The system is depicted in Figure 3.

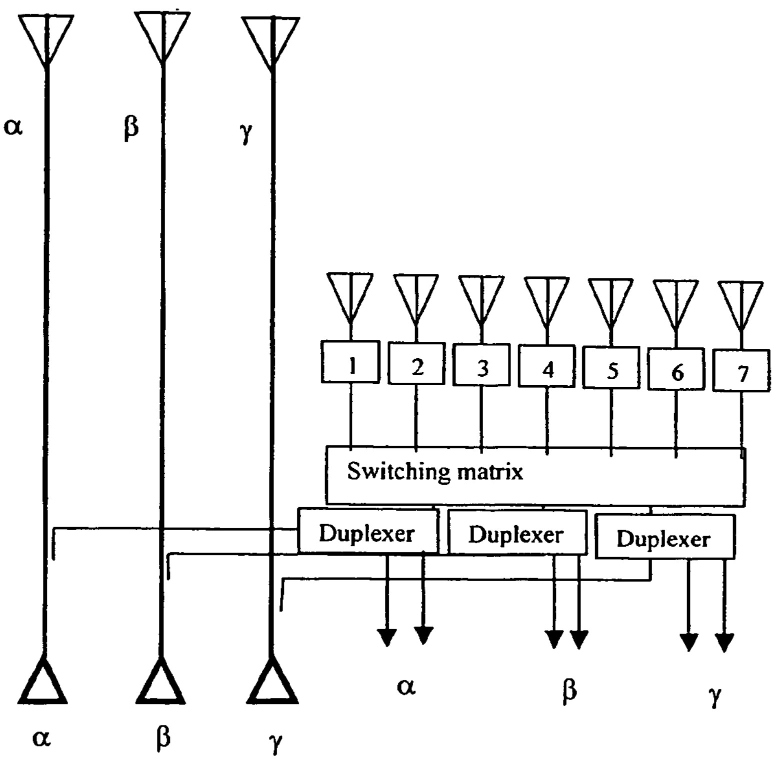

Figure 3: Point-to-point linkage to thc BTS

The RF converter translates the base frequency (F1) to the repeater link microwave frequency (F_{MW}) .

This configuration controls each one of the access points and may link each repeater to each sector. The gain of each access point is controlled from the central command, thus controlling the coverage and capacity each one draws.

Note that the coupler may be attached before the power amplifier (subject to accessability).

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The linkage can further be materialized by RF transmission between the BTS to the switching matrix, in a case where there is an advantage to physical separation between the BTS and the repeater distribution complex.

Also, a full sector may be dedicated to the remote extensions. In such a case the switching matrix is fed by one input. This is a method to increase the cell's capacity (by incorporating a 4-th sector in the cell), without changing the geographical setup.

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In yet another embodiment of the invention, the RF linkage to the repeaters is done using one omni antenna, and the separation is achieved in the frequency domain.
In this case we use for each repeater (or group of repeaters) a different unused frequency in the PCS/Cellular band.
The system is depicted in Figure 4.

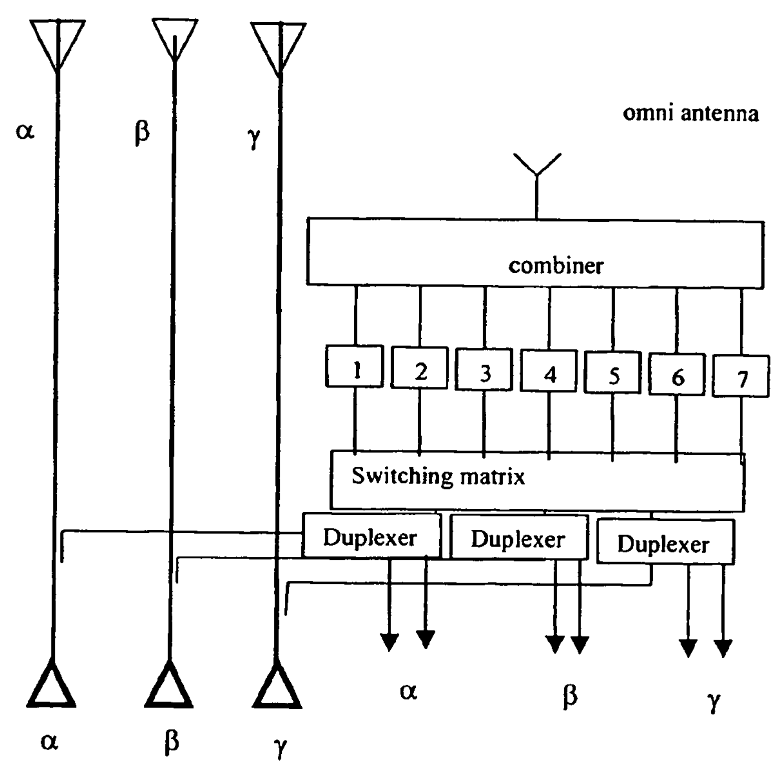

Figure 4: Linkage to repeaters by frequency control using an omni antenna

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Load measurements

Load measurements are required for any load balancing and network optimization, whether the balancing is done manually, to adapt the network to slow changes, or dynamically, using optimization algorithms.

Since load balancing involves repeaters, the contribution of each repeater should be known, as well as the total load of each sector. Furthermore, the load should be monitored periodically, especially when dynamic optimization is required.

Any efficient load measuring technique and method can be used. For example, Uplink measurements (noise rise), Downlink measurement (total transmitted power), counting the number of users (at the sector level), or a combination of these techniques.

Similarly, any technique and method for the differentiation between the direct load of the sector and the contribution of the load through the repeaters can be used. For example, marking the repeater signal (in the downlink or in the uplink) and monitoring the mark, or measuring the uplink repeater signal at the switching matrix.

Once the loads are determined, we can use an efficient algorithm to perform the load balancing.

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Claims

1. load balancing system containing:

   - Sectored base station

   - Several repeaters (at least one) with local coverage, in the sectors (at least one)

   - switching matrix, connected (on one side) to the RF outputs of the Base station, and (on the second side) to frequency converters

   - a mechanism which control the switching matrix

2. A load balancing system according to claim 1, wherein the frequency convertion is from the base RF frequency (F1) to another frequency (F2) in the same PCS/cellular band, and the legacy antennas are used.

3. A load balancing system according to claim 2, wherein F1 and F2 are multi-carrier (group F1 and group F2)

4. A load balancing system according to claim 2, wherein different repeaters (and correspondingly the RF converters) are tuned to different F2 frequencies.

5. A load balancing system according to claim 1, wherein F2 is in a different frequency band (licensed or unlicensed) and additional dedicated antennas are used.

6. A load balancing system according to claim 1, wherein we add an omni antenna (radiating equally in all directions), and each repeater (and correspondingly the RF converter) is tuned to a different F2 frequency.

7. A load balancing system according to claim 1, wherein the switching matrix is not near the BST but in a different location and is connected to the BST with a communication link.

8. A load balancing system according to claim 7, wherein the serving sector comes from a different cell.

9. A load balancing system according to claim 1, wherein the system contains a load measurement apparatus and the control mechanism of the switching matrix is driven by an optimization algorithm based on load measurements.

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10. A load balancing system according to claim 9, wherein the load measurements are based on the total received power (noise rise)

11. A load balancing system according to claim 9, wherein the load measurements are based on the total transmitted power

12. A load balancing system according to claims 10 and 11, wherein the load is a combination of those and the number of users served by each sectors.

13. A load balancing system according to claim 12, wherein the load measurements are also performed for each repeater (in addition to the measurements on the sector level).

14. a method (algorithm) based on load measurements, to control the switching matrix.

15. a method (algorithm) based on load measurements as in claim 14, wherein the measurements and control are performed dynamically with changing loads.

16. a method (algorithm) based on load measurements as in claim 14, wherein the measurements and control are initiated by the operator.

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